The first impression made by the table of occupations is that of diversity, 266 different occupations being represented. They include all varieties of work, and the occupations range from unskilled laborers to tradesmen, skilled craftsmen, business men, artists, and professional men. The seven classes of men contributing the highest numbers are as follows:

Laborers	1,063
Farmers	236
Salesmen	178
Clerks	148
Carpenters	121
Machinists	116
Railroad employees	112

Among the women the following occupations give the highest number:

Housewives	551
House workers	153
Domestics	93

In interpreting these figures it must be remembered that those classes of occupations showing the highest number of persons insane because of syphilis are, for the most part, the preponderating occupations of the country. That is, the fact that 1,063 laborers and 236 farmers were found to be insane because of syphilis does not mean that laborers are more apt to go insane because of syphilis than farmers, as there are many more laborers than farmers in the population of the country.

It is believed that the only deduction that can justly be made from the list of occupations is that those who go insane from syphilis are not confined to any one class, but that they are drawn from practically all classes and all occupations.

In conclusion, attention should be called to the fact that this paper deals only with the incidence of mental disorders due to syphilis arising among persons under public care. As a sequel to this article it would appear to be valuable for some studies to be made in regard to the duration of insanity due to syphilis and the length of stay in the hospital in order that some deductions may be drawn to show economic losses.

REPORT ON INVESTIGATION OF TYPHOID FEVER EPIDEMIC AT GREENEVILLE, TENN.[1]

By C. N. Harrub, Associate Sanitary Engineer, United States Public Health Service, in cooperation with the Tennessee State Board of Health.

During the period April 6 to June 20, 1920, an outbreak of typhoid fever occurred in Greeneville, Tenn., with a total of 61 cases and 7 deaths (1 case and 1 death occurring in the county outside the town

[1] From report made by the writer to the State Board of Health of Tennessee.

of Greeneville); and, in response to a request from the officials of that city, I made an investigation into the cause of the epidemic.

Water Supply.

As the previous history of the water supply showed it to be of inferior quality, an examination of the supply, with sanitary survey, was made as the first step in the investigation.

The water is obtained from a spring which issues from under a limestone ledge almost in the center of the city. It is located in the bottom of a basin toward which a large part of the town drains. A concrete pool has been constructed at the spring, but it affords very little protection against contamination. A small house is built over the intake, but the pool is open. From this upper pool the water is piped to a second open pool at the pumping station, located on the edge of a small creek which is the main drainage channel for the city. From this pool the water is pumped to the reservoir, whence it flows by gravity to the city. During the epidemic of typhoid fever in 1913 a hypochlorite plant was installed to disinfect the water before it was pumped into the reservoir. The hypochlorite solution was discharged into the pool at the pumping station, a few inches from the end of the suction main.

The plant is owned by the city, and about 90 per cent of the people are served with city water. The present daily consumption is about 500,000 gallons. During the dry weather the supply is not sufficient to meet the demands and it is necessary to restrict the use of water to necessary purposes only.

Sanitary Survey.

The sanitary survey revealed a very unsatisfactory condition. As stated above, the location of the spring is extremely bad. It is in practically the lowest spot in town and is surrounded by dwellings. Previous to the establishment of a public water supply, private wells were used. Some of these have been proved by test to be directly connected with the source of supply of the spring. During the digging of one of these wells, the owner noted that while finishing the well the spring ran muddy; and in another instance dye placed in the well came out through the spring. Surface drainage from a large area runs directly to the spring. A concrete storm sewer has been built which discharges into the small creek just below the spring. In times of heavy rain this creek floods back into the spring. A flap valve has been put on a pipe which passes through the concrete wall surrounding the pool, but it is tipped back on the pipe, and therefore does not close. It is very doubtful whether it would be of any advantage if put into operation, as it would not close tight.

Since the installation of the public water supply many wells have been abandoned, and others have been used as cesspools. The one

tested with dye was so used, and, as shown by the test, was contributing pollution directly to the spring. Cesspools were in common use in the drainage area of the spring, and undoubtedly all are polluting the underground waters which find their outlet at the spring.

At the lower pool near the pumping station there is only a concrete wall between the water supply and the polluted creek. There are several open pipes through this wall, and when the creek is flooded these pipes are sometimes submerged. At such times cotton waste is stuffed into the pipes to keep the creek water out as much as possible; but this affords very poor protection against so polluted a stream.

The hypochlorite plant, which was relied upon to safeguard the people of the city against typhoid fever and other water-borne diseases, originally consisted of a mixer, two solution tanks, and an orifice box. One of the solution tanks has been out of commission for the past three years, and it has therefore been necessary to rely on one solution tank. This necessarily prevents proper operation of the plant, as it does not allow any opportunity for the solution to settle. Consequently, the suspended lime passes to the orifice box, where it may partially clog the orifice and reduce the flow of the solution and result in only partial disinfection of the water. The lime also gives trouble in the solution feed pipes. It has been customary at this plant to keep the solution stirred, so that even were the two solution tanks in service, these troubles would be experienced. It was apparent that the hypochlorite plant was not doing the work it was thought to be doing and was not sufficient protection to the water consumers.

The spring has been known to be contaminated for a long time. According to the superintendent of the waterworks, all the analyses for the past eight years have shown the presence of sewage organisms. Only three of these analyses are available, the results of which are shown below:

September 22, 1917:	
Bacteria per c. c., 37° C.	600
Bacteria per c. c., 20° C.	580
B. coli present.	
July 7, 1919:	
Bacteria per c. c., 37° C.	3,000
B. coli, 10 c. c.	5+, 0−
B. coli, 1 c. c.	1+, 0−
May 19, 1920:	
Bacteria per c. c., 37° C.	6,440
B. coli, 10 c. c.	5+, 0−
B. coli, 1 c. c.	1+, 0−

Samples were sent to the State board of health laboratories just previous to my arrival in Greeneville. The information sent with the

samples as to the source is not sufficient to show whether they are all from the public supply; but two of them marked "Mason" and "Spring" are very bad, while two marked "Tucker" and "Davis" are good. The results of analyses of these samples are shown in the following table:

Analyses of samples of water.

	Source.			
	Davis.	Tucker.	Spring.	Mason.
Bacteria per c. c., 20° C.	44	110	1,500	800
Bacteria per c. c., 37° C.	30	90	1,200	670
B. coli, 10 c. c.	0+,5−	0+,5−	5+,0−	4+,1−
B. coli, 1 c. c.	0+,3−	0+,3−	2+,1−	2+,1−
B. coli, 0.1 c. c.	0+,3−	0+,3−	1+,2−	1+,2−

On account of the condition of the water supply and the unreliability of the hypochlorite plant, steps were immediately taken to provide positive disinfection of the supply. An emergency liquid chlorinator had been taken to Greeneville from the State board of health, and through the courtesy of Dr. Yancy, city health officer of Kingsport, a cylinder of liquid chlorine was obtained from that place and put into service as soon as possible. When the chlorinator was operating satisfactorily, the hypochlorite plant was discontinued.

A visit was paid to each of the practicing physicians to get a list of their cases of typhoid fever during the outbreak. The dates of onset of the various cases are shown in the accompanying table.

In addition to the 60 cases and 6 deaths recorded in the table, there was one case in the county outside of Greeneville which was fatal, making a total of 61 cases and 7 deaths during the epidemic. This corresponds to a morbidity rate for the epidemic period of 2,033 per 100,000 population, a death rate of 233 per 100,000 population, and a mortality percentage of 11.5.

A study of the data collected reveals the following facts: One hundred per cent of the cases used city water for drinking, all or part of the time, and 84 per cent used it exclusively. Four, or 13 per cent, used cistern water in part, and one used water from a spring at his home in the country. In no case was the drinking water boiled previous to the appearance of the disease.

Investigation into the milk supply and the use of uncooked vegetables and ice cream showed that these were unrelated to the outbreak.

Nineteen, or 61.3 per cent, of the cases investigated occurred in houses connected to the sewer; 10, or 32.3 per cent, were not connected to the sewer; 1 lived beyond the limits of the sewerage system, and for 1 the information was not obtained. In the 10 cases not connected to the sewer, open surface closets were used. None

of these was fly proof or in a sanitary condition. In every instance, except the one from the country, the street on which the patient lived is sewered, and proper means of disposal of sewage is provided. In three instances where the sewer connection had been made, a surface closet was still maintained on the premises. One of those, however, was not used at the time of the investigation.

Dates of onset of cases of typhoid fever in Greeneville, Tenn., and number of cases by weeks, Apr. 6 to June 26, 1920.

Cases by date of onset.		Number of cases by weeks.	
Date.	Number of cases.	Week ended—	Number of cases.
Apr. 6	1	Apr. 10	1
Apr. 15	2	Apr. 17	2
Apr. 20	1	Apr. 24	1
Apr. 26	1		
Apr. 30	2		
May 1	[1] 5	May 1	8
May 2	[1] 2		
May 3	1		
May 4	2		
May 5	[1] 1		
May 7	[1] 3		
May 8	1	May 8	10
May 10	1		
May 14	1		
May 15	[1] 2	May 15	4
May 16	1		
May 17	1		
May 19	1		
May 21	1		
May 22	1	May 22	5
May 23	1		
May 27	[1] 1		
May 28	1		
May 29	1	May 29	4
May 30	5		
June 1	1		
June 2	1		
June 3	1		
June 4	2		
June 5	1	June 5	11
June 6	2		
June 7	4		
June 8	2		
June 10	2		
June 12	1	June 12	[2] 11
June 17	1		
June 18	1	June 19	2
June 20	1	June 26	1
Total	60		60

[1] One of these cases died. Total deaths, 6. [2] Chlorinator installed June 12.

Only two of the cases had been away from the city during the two weeks previous to the onset of the disease. One of these had visited Bristol and had been sick in bed two days while there.

Three instances were found where more than one case occurred to the family. In one of these there were five cases, three of which were possibly secondary cases from the first case. The mother was first taken sick; 5 days later the father was taken down, and 15 days after the mother became sick two of the children became ill and a third child about two weeks later. There is no sewer connection

from the house where this family lives, and the excreta were discharged on the ground. A case of typhoid occurred next door to this place 10 days after the two children were taken sick. So far as ascertained this was the only place where a case occurred in the immediate neighborhood of a previous case where a surface toilet was used.

So far as learned none of the persons afflicted had ever been vaccinated with antityphoid vaccine, although the question was not asked in every case. Vaccination among other members of the family was very generally practiced after the occurrence of the first case in the family. An attempt was made to arrange for free vaccination for those persons unable to pay, provided they furnished their vaccine. Each of the practicing physicians was to give one hour per week to this work. Later advices indicated that this scheme did not work out as planned, and practically nothing was done.

On account of a local feeling that the ice furnished by the Greeneville Ice Co. might be responsible for the typhoid outbreak a special inspection of the ice plant was made. The raw-water system is used in manufacturing the ice; that is, the water is not distilled before use. Instead, it is kept agitated by air to prevent the inclusion of foreign matter during the freezing process. City water is used.

A dual connection between the city water and the water from the polluted creek mentioned earlier in this report was found. This arrangement was made so that either city or creek water could be used for condensing the ammonia. The city water used in ice making is drawn from the same pipe only about 10 feet from the valve separating the two waters, and if for any reason the city water was cut off or failed while the creek water was being used for condensing, the creek water might be drawn into the filling tank and used in making ice. It was urged that this dual connection be done away with and city water used altogether for condensing purposes.

A study of the locations of the cases indicates a general source of infection rather than fly dissemination from local foci. One thing which at first was without apparent explanation was that very few cases of typhoid occurred on the east side of Main Street. In endeavoring to determine the reason for this it was learned that there are several small springs in that part of town, at least two of which are used quite generally by people in the vicinity as a source of drinking water. These springs were examined and samples of the water taken to the laboratory for analysis in order to compare them with the city water. One of these springs is located on the old Andrew Johnson property and the other is known as the Parks spring. The former is poorly protected against pollution, a tile pipe placed vertically in the spring to prevent the sides from caving in being the only attempt at protection. The Parks spring has been concreted and housed, but steps lead down to the level of the water

and polluting matter may be carried in on the feet of people going after water. The analyses of these waters are as follows:

	Johnson.	Parks.
Bacteria per c. c., 20° C	1,100	500
Bacteria per c. c., 37° C	1,090	420
B. coli, 10 c. c	4+, 1−	3+, 2−
B. coli, 1 c. c	2+, 1−	1+, 2−
B. coli, 0.1 c. c	1+, 2−	0+, 3−

Although these analyses indicate that the water from these springs is far from pure, it is much better than the city water, especially that from the Parks spring. The absence of typhoid fever in that part of the city is probably due to the use of water from these springs. The presence of sewage organisms in both springs shows them to be potentially dangerous, and it should be borne in mind that the appearance of a single case of typhoid fever in the area contributing to these springs might infect them and thus spread the disease among all the users of this water.

The city is from 85 to 90 per cent sewered, and probably 93 per cent of the people could be served by the sewers; yet only about one-third of the houses are connected. The city passed an ordinance which requires connection wherever the sewers are available; but it has not been enforced, mainly because of the inadequacy of the water supply. During the dry summer months the supply has not been sufficient for the demands for the past few years, and increased use of inside flush closets would still further deplete the supply and cause more serious shortage.

The inspection of the waterworks plant revealed immediately the danger of incomplete disinfection of the water and of the occurrence of an epidemic of water-borne disease. This was explained to the board of water commissioners at a special meeting called for that purpose, and the necessity for immediately securing and installing new and efficient apparatus for constantly sterilizing the water was shown. As a result of this meeting, the superintendent was authorized to order a liquid chlorinator and two cylinders of chlorine. These orders were sent immediately. In the meantime the emergency apparatus furnished protection to the city.

It was also explained to the commissioners that providing proper sterilization of the water is only the first step toward securing safe water, and that filtration, followed by disinfection, is necessary if a safe, as well as a clean, water is to be furnished at all times.

In response to inquiry as to the comparative cost of operation of a liquid chlorinator and the use of hypochlorite of lime for disinfecting the water, it developed that the estimated cost for liquid chlorine was about four times the actual amount paid last year for hypochlorite, notwithstanding the fact that the cost per pound for liquid

chlorine is less than two-thirds the cost per pound of available chlorine in the hypochlorite. The only inference that could be drawn from this is that instead of using an average of 6 pounds of hypochlorite per day, as stated, the actual average was about 1 pound per day. This would correspond to about 0.07 p. p. m. available chlorine, which would not be sufficient to produce the required disinfection. The above figure is based on 33⅓ per cent available chlorine, and is about the maximum that could be expected.

Conclusions.

The following conclusions were drawn as a result of this investigation:

1. The city is suffering from an epidemic of typhoid fever which is undoubtedly caused by a polluted water supply. The data collected indicate that the water supply is the responsible agent.
2. The water supply of Greeneville is grossly polluted and is a constant and serious source of danger to the health of the community.
3. The location of the spring from which the water is obtained is such that it is practically impossible to prevent the access of polluting matter.
4. The spring is the outlet for the ground water under a large portion of the city.
5. On account of the limestone formation underlying the city there is practically no natural purification of the seepage from open-surface closets and cesspools before reaching the ground water, and the ground water underneath the entire city is probably polluted by sewage.
6. The old hypochlorite plant which has been relied on to protect the city against water-borne diseases is worn out, unreliable, and not a sufficient safeguard.
7. The hypochlorite plant has not been operating as efficiently as it was believed to be and has undoubtedly allowed water only partially disinfected to enter the mains.
8. The installation of apparatus to insure constant and efficient disinfection of the water is immediately necessary.
9. Filtration of the water is necessary if a clean as well as safe supply is to be provided.
10. The present supply is entirely inadequate, and provision for a permanent, adequate supply should be made as soon as possible.
11. The present storm sewer which discharges into the creek just below the spring is a menace to the health of the community on account of the fact that in times of heavy rain the storm water is forced back into the spring which supplies the city with water.

12. The city has averaged from 30 to 35 cases of typhoid fever a year for the past eight years, and during all that time the spring has been known to be polluted. Typhoid fever will continue to be prevalent until efficient purification of the water supply is provided.

13. The town is well sewered, but on account of an inadequate supply of water the sewerage system is very little used.

14. The present practice of using cesspools and surface privies tends to a continuance of typhoid fever in the community.

15. Two things are therefore absolutely necessary if the city is to obtain any permanent relief from the scourge of typhoid fever: (1) An adequate and safe water supply; (2) compulsory use of the sewers and abandonment of all cesspools and privies in the sewered districts.

Recommendations.

The following recommendations were made for the improvement of the water supply and to aid in stamping out typhoid fever from Greeneville:

1. Install immediately a liquid chlorine plant and insure thorough disinfection of the water before delivery to the citizens.

2. Secure as soon as possible a temporary additional supply to prevent a shortage of water during the coming summer and fall.

3. Take steps immediately to provide for filtration of the water supply as the only means by which the water can be made clean as well as safe.

4. Proceed at once with the work of securing an adequate supply of water, either from the Nolichucky River or from some other source which can be depended upon for an unfailing supply. Such supply should be filtered and disinfected if from any surface source, and the filtration plant recommended above for the present supply would be available for that purpose.

5. As soon as the temporary additional supply of water is obtained, compel connection to the sewer from every house on sewered streets; remove all surface privies and fill all cesspools in the same sections.

These recommended improvements can not be too strongly urged. Money spent in improving the water supply and eliminating typhoid fever is well invested and will pay big returns. The present epidemic of typhoid has cost the city more in actual money than would the measures which would have prevented it, to say nothing of the suffering and deaths. It is much more expensive to maintain typhoid fever in the city than to get rid of it, and no better investment can be made by the city than that of buying freedom from this preventable disease.